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COMPARISON OF ECONOMICS OF WINTER PRODUCTION OF HORTICULTURAL PRODUCTS IN GREENHOUSES IN THE U.S. WITH OUTDOOR PRODUCTION IN AREAS DISTANT FROM THE MARKET

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One of the characteristics of economic analysis that helps make the field interesting and alive is the constant change in costs and returns. However, the changes in fuel availability and cost over the past few months have been so violent and their effects on any comparison of greenhouse production near market and field production distant from market have been so profound as almost to defy comprehension. Certainly the changes, if permanent, will cause completely different relationships of prices to costs in the various competing areas than those that existed before October 1973.

This analysis will therefore be much more tentative than was intended when the assignment was accepted. Data suitable for use in the analysis were already sparse and fragmentary, but now major new calculations and revisions are required. Adding to the uncertainty in computations is the proliferation of political interventions aimed at preventing market forces from guiding decision-making. The necessarily arbitrary political decisions under Phase IV, and any later phases, may well upset any calculations made.

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While such considerations are becoming more and more normal in business decision-making, they are currently of such overriding importance that the reader should be more than usually wary of any conclusions regarding the economics of greenhouse and distant production based on the current situation. If this sounds like a wish to return to the "good old days," the author will admit this idea has come to mind.

The comparison of the economics of vegetable production near to and distant from areas of consumption appears at first glance to be a classical exercise where the use of a transportation model and of production cost information in the competing areas could provide rather precise answers. However, several constraints limit the choices in each area and complicate the economic calculation. These constraints may be classified as follows:

1. Biological
2. Geographic
3. Political

Each of these affects costs and returns and helps determine relative risk levels in production in each area. Together they determine where each winter vegetable can be grown economically.

Biological Constraints -- The major biological constraints are those related to the physical and economic capabilities of each vegetable for out-of-season production and for storage, handling and transport. Because of biological characteristics, the tomato, for instance, will not yield an

economic crop in the major U.S. greenhouse areas during January, February and March because of low light conditions and the market during this period is almost wholly supplied by tomatoes from distant producing areas. In the U.S., it is largely during November-December and April-May-June-July that active competition for the tomato market occurs between greenhouse and distant areas.

The plant breeder is constantly striving to reduce the effect of biological constraints with successes sometimes to the temporary advantage of the greenhouse grower and sometimes to the advantage of the climatically favored grower. Disease resistance, increased yield potentials and improved quality and appearance characteristics are being incorporated each year in new plant materials available to producers.

Geographical Constraints -- Geographic location determines both climate and distance to population centers. Because of the biological nature of vegetables, both these characteristics provide economic constraints to location of vegetable production. Northern areas near population centers require little transport for vegetables produced, but require large amounts of heat to offset the cold climate. Distant areas have little need for environmental controls, but have major marketing requirements including transport time and cost in supplying population centers with vegetables. Technological advances in knowledge of vegetable handling and in transport equipment along with improved highway systems have reduced the previous advantages of location of vegetable production areas near to population.

Political Constraints -- Since greenhouse vegetable production in the U.S. is local and domestic while production in climatically favored outdoor areas is quite distant and sometimes in a foreign country, political constraints for the two areas may be quite different. The national and state boundaries with resultant customs duties, quota restrictions, grade, grading, packing and labelling restrictions and uncertainties in political and institutional arrangements may have a quite different effect on the greenhouse and distant producer. While most of these favor the nearby over the distant producer, the recent experience in political controls over fossil fuels, internationally and internally, has demonstrated the vulnerability of any and all producers in any location to such factors.

U.S. Greenhouse Vegetable Industry

In the 1969 U.S. Census, 575 acres of greenhouses for vegetable production were reported in the U.S.[1] Independent estimates placed greenhouse vegetable acreage harvested at 2920 acres in 1971, of which about 1500 acres were from plastic houses.[2] Regardless of the degree of underreporting in the census, and most of this reported greenhouse vegetable acreage would produce two or more crops annually, the acreage of glass greenhouses apparently has remained quite stable in recent years while that of plastic greenhouses has increased. Total acreage of greenhouses for all crops in the U.S. has continued to increase since 1889, while the acreage in greenhouse vegetables has not.

Tomatoes were by far the major greenhouse vegetable crop, with 63 percent of the acreage and 78 percent of the value of product in 1969 (Table 1).[3] Many greenhouse vegetable growers who grew lettuce also grew a late crop of tomatoes after one, two or even three lettuce crops. Others grow two tomato crops a year, one planted in August and harvested October-December and the other planted in January or February and harvested April-July. Cucumbers, once an important crop, are again attracting grower attention because of the consumer popularity of the recently introduced English or Dutch type, a mild, seedless cucumber.

Because of the greater importance of tomatoes and the greater amount of data available on the tomato crop, the remainder of the analysis will deal primarily with fresh tomatoes. The same principles apply to comparisons for other greenhouse vegetable crops.

Nature of Competition

The comparative advantage of winter tomato production in greenhouse versus climatically favored areas distant from the markets is a constantly changing one, with temporary advantages to each area. Personal observation over the past 21 years and conversations with growers whose experience goes back another 20 years has suggested that the competitive position of the U.S. greenhouse producer has become less and less favorable during the past 20 years. Production costs have risen more than wholesale prices for greenhouse tomatoes (Table 2).[4] Temporary improvements in the competitive situation for

TABLE 1

AREA AND VALUE OF LEADING GREENHOUSE CROPS IN THE UNITED STATES, 1969[a]

Crop	Total Area[b] (acres)	Value Per Acre (dollars)	Total Value (dollars)
Tomatoes	651.4	29,555	19,252,038
Lettuce	272.0	12,638	3,437,606
Cucumbers	36.2	21,710	785,918
Other	69.3	17,740	1,230,037
All Vegetables	1,028.9	24,012	24,705,599

[a]Excludes Alaska and Hawaii

[b]Area planted

SOURCE: 3

TABLE 2

TRENDS IN PRICES OF OHIO GREENHOUSE TOMATOES AND FARM PRODUCTION COSTS, 1940-70

Year	Average Price 8 lb. Basket U.S. No. 1 Med. Ohio GH Tomato[a] (dollars)	Tomato Prices in 1967 (dollars)	Retail Fresh Tomato Prices (cents/lb.)	Index of Prices of Farm Production Inputs (1967 = 100)
1940	0.99	2.44	--	36
1950	2.17	2.65	24.3	75
1960	2.39	2.52	31.6	88
1970[b]	2.80	2.54	42.0	114

[a]SOURCE: 14

[b]Estimate based on market news summaries

the greenhouse grower have occurred in winter seasons where freezes, hurricanes, tropical rains, rainy spells, winds and other unfavorable weather conditions have damaged or destroyed outdoor production. Without the occurrence or the threat of the occurrence of such natural disasters to outdoor production, competition to the greenhouse producers would have been much greater than it has been. Temporary improvements also have come from political action favoring the domestic producer such as the forbidding of vegetable imports from Cuba, the control of grade and size of imports from Mexico and from Florida through restriction imposed under the Federal Marketing Order for Florida Tomatoes.

On the positive side, greenhouse producers have been favored by the development and improvements in automatic electronic controls, in breeding of higher yielding, disease resistant varieties, and by improved production practices such as increased horticultural knowledge in the use of CO_2 enrichment, more effective fertilizer usage and irrigation.

Improvements favoring the distant outdoor producer have been almost as striking as for greenhouse operators. Improved varieties and improved horticultural practices have been developed and adopted by producers. However, the major development during this 40-year period has been the opening of new areas in Mexico as major winter tomato supply areas. This development has been aided by the export of technological and management know-how in the form of California vegetable growers. These growers have helped in the transfer of the latest California research developments to areas

with similar growing conditions in Mexico. This process undoubtedly was speeded and made more financially attractive by Federal legislation forbidding the use of Mexican braceros in tomato harvest in the U.S.

Climatic conditions in western Mexico in the winter season are more nearly ideal for vegetables than in Florida and Mexico has become the most important single supplier of winter season tomatoes for the U.S. market. Between 1963-64 and 1969-70, Mexican vine ripe tomato shipments to the U.S. market increased from about 5.2 to 14.3 million 40-pound unit equivalents (Table 3). Shipments from Florida declined and those from other areas, including greenhouse, increased only slightly during this period.[4]

Two recent developments are of significance in the extension of production in environmentally controlled areas. One is the increased interest in and experimental commerical construction of greenhouses, mostly plastic, in areas distant from market where light conditions are satisfactory for January-February-March tomato harvest and where heating requirements are less costly and low humidity makes cooling by evaporation feasible. The second is the interest in the possibility of artificial light and the "growth chamber" approach to production in areas such as northeastern U.S. Some commercial use has been made of the growth chamber in producing superior transplants. A disadvantage in greenhouse location in an area such as southern California or Arizona, in addition to the transport requirement, is the need for refrigeration or cooling equipment to control the excessive heat that characterizes the early spring weather in these areas. Present greenhouse production in these areas is largely for the local market and there is

TABLE 3

CHANGES IN TYPES AND SOURCES OF WINTER TOMATOES, 1963-64 THROUGH 1969-70

Season	Vine Ripe			Mature Green			Mixed Types Other Areas	Total Shipments
	Florida	Mexico	Total	Florida	Mexico	Total		
	(Million Units -- 40-Pound Equivalent)							
1963-64	3.9	5.2	9.1	13.1	2.4	15.5	12.9	37.5
1964-65	5.3	6.5	11.8	11.5	1.6	13.1	14.3	39.2
1965-66	6.1	8.9	15.0	11.1	0.9	12.0	14.2	41.2
1966-67	4.8	10.4	15.2	12.4	0.5	12.9	12.6	40.7
1967-68	4.2	9.9	14.1	12.4	0.1	12.5	14.4	41.0
1968-69	3.5	11.3	14.8	10.5	1.3	11.8	14.9	42.6[a]
1969-70	1.7	14.3	16.0	8.7	1.8	10.5	15.6	43.7[a]

[a]Includes cherry-type tomatoes: 1.1 million units in 1968-69 and 1.6 million units in 1969-70.

SOURCE: 4.

too little information at this time to determine probable future development as an alternative to outdoor or nearby greenhouse production for northeastern U.S. markets.

To be economical in utilizing their plant investment, it is likely that the harvest season for these greenhouses will have to be extended into April, May and June to compete directly with existing greenhouse producers near population centers and with outdoor production areas.

Fresh Tomato Consumption

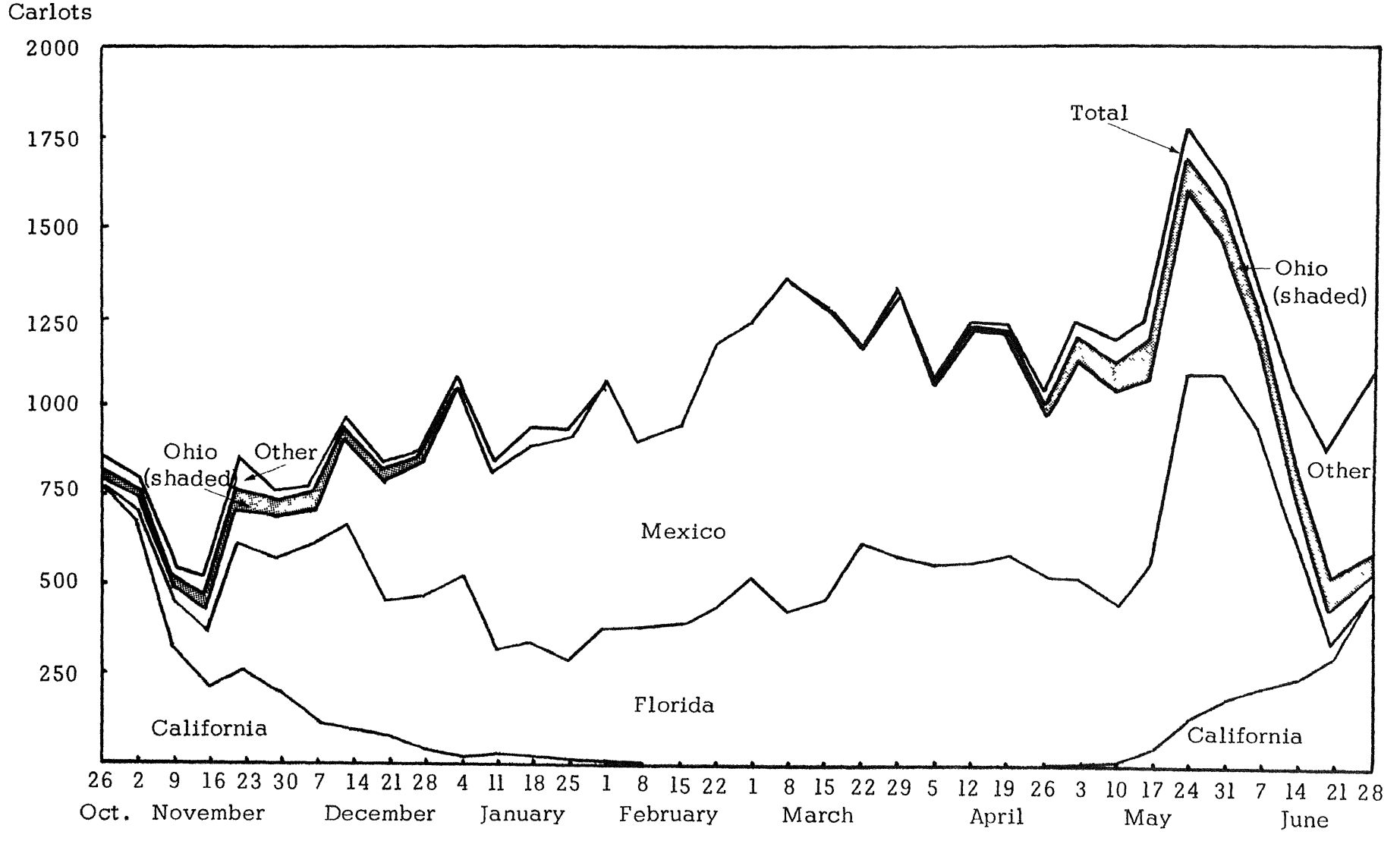
Availability of good quality fresh tomatoes, each month of the year, is a relatively recent development in the U.S. market. Until the 1950's, the northern consumer had to depend on greenhouse tomatoes for good quality tomatoes in November-December and April-May-June. Essentially, the only fresh tomato available in the January-February-March period and the major non-greenhouse supply during November-December and April-May-June was the mature green or green wrap tomato known in the trade as the "tube" tomato because of the common method of packaging of three or four tomatoes in line in an overwrapped tube for retail sale. This tomato is harvested 10 days to two weeks prior to the vine ripe stage of maturity then ripened in ripening rooms after reaching the wholesale market. The advantage is that the product is a non-perishable product suited to the long hauls and the variable holding periods encountered in the marketing channels. The disadvantage is the inferior eating quality as viewed by the consumer.

Major improvements in highways shortly after World War II and continuing improvements in transport equipment, including refrigeration and environmental controls, have greatly expanded the scope of fresh vegetable transport in the U.S. Starting in the 1950's, alert growers and shippers in distant areas began shipping tomatoes harvested at or near the vine ripe stage. These tomatoes were much more perishable and much higher in market quality, and as a result they commanded a price premium over mature green tomatoes. They also furnished increased competition to greenhouse tomatoes over that given by mature green tomatoes. The vine ripe producers concentrated on the January-March period, when few greenhouse tomatoes are harvested and the only competition was the mature green tomato. Each year the vine ripe marketing period has been extended so that it now competes with the greenhouse tomato during the entire greenhouse harvest period.

Fresh tomatoes are consumed in large quantities each month of the year and frequently rank in value ahead of the value of lettuce as the number one fresh vegetable. The sales record for a large national chain retailer indicates that consumption during May, the highest month, is more than twice that for November, the lowest month (Figure 1).[5] Consumption is higher than indicated by supermarket sales in July, August and September because of the considerable volume produced in home gardens or purchased directly from farmers and farm markets by consumers. It is of interest and significance that the peak in fresh tomato consumption coincides with the peak harvest season for greenhouse tomatoes and that tomato prices during the April-June period are normally equal to or greater than those in either earlier or later months.

Figure 2

TOMATOES: WEEKLY CARLOT MOVEMENT FROM PRINCIPAL PRODUCING AREAS DURING THE FLORIDA 1968-69 SEASON

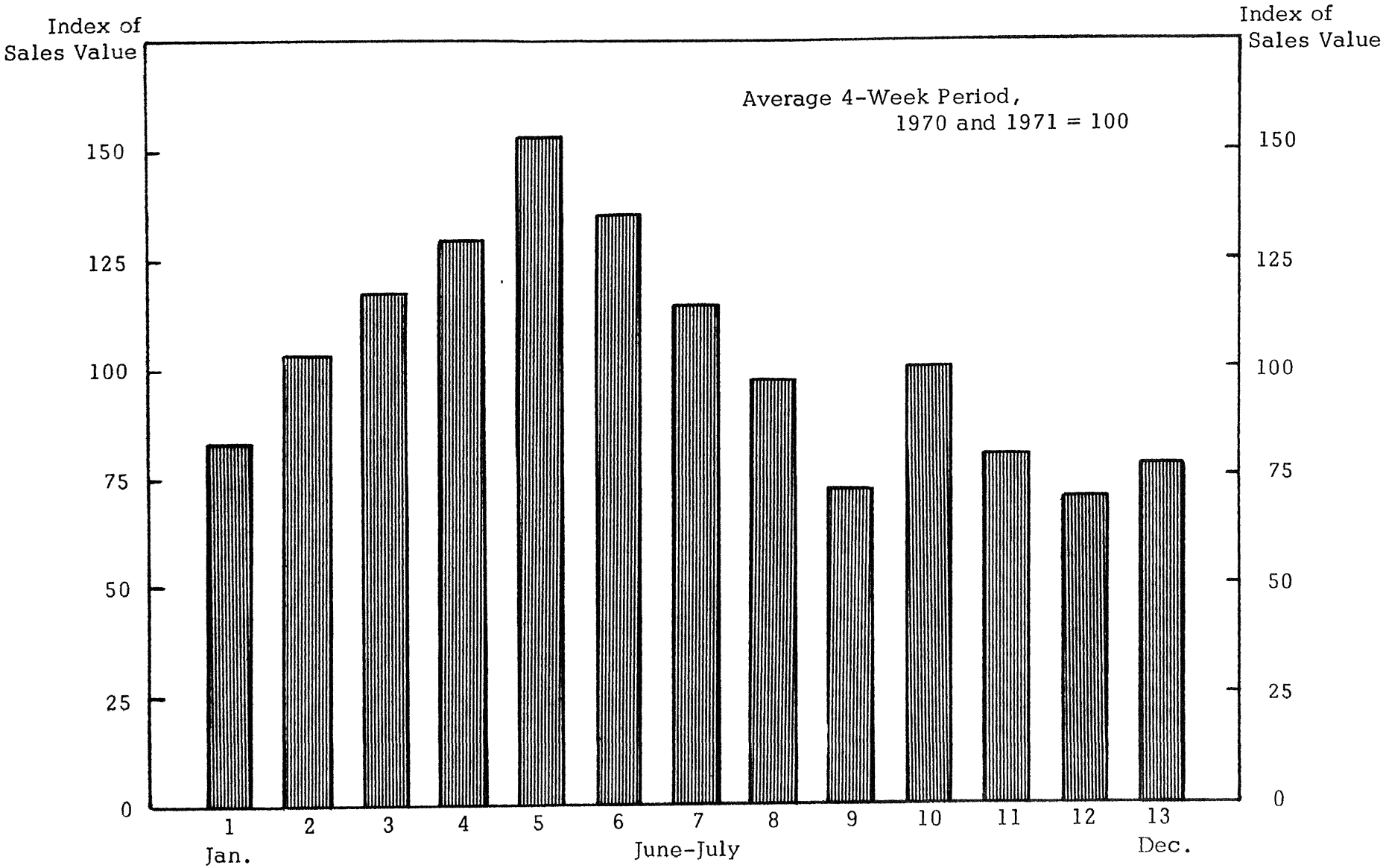


Greenhouse tomatoes account for only a small percentage of fresh tomato consumption in the U.S., possibly two percent of total and 3.2 percent of winter season tomatoes.[6] The winter tomato supply, October-June, is overwhelmingly from Florida and Mexico with California an important supplier in October and June only (Figure 2). However, in Cleveland, Ohio, which is located near the major greenhouse vegetable area in the U.S., the April-July market percentage accounted for by Ohio greenhouses in 1963 was 81 percent of total tomatoes used. For the same time period, 6.0 percent of Chicago and 2.7 percent of New York City unloads were supplied by Ohio greenhouse producers.[7] In June, Ohio greenhouses furnished about 23 percent of the total tomato supply in the twelve top Midwestern and Eastern markets. No attempt was made to estimate the destination of the approximately 20 percent of total greenhouse tomatoes produced outside Ohio.

In May, 1972, about 7 percent of U.S. supplies of tomatoes were from greenhouses and in June about 6 percent (Table 4). For the entire winter period, January-June and November-December, greenhouse tomatoes accounted for 3.2 percent of total unloads, while for the entire year they accounted for about 2.1 percent of the total. The year 1972 was one of the few recent years where more U.S. winter tomato supplies came from Florida than from Mexico.

Figure 1

AVERAGE FRESH TOMATO MOVEMENT BY FOUR-WEEK PERIODS
LARGE CHAIN RETAILER , 1970 AND 1971



SOURCE: Personal letter from Buyer-Merchandiser for large supermarket chain.

TABLE 4

SOURCE OF TOMATO UNLOADS AT 37 MAJOR U.S. TERMINAL MARKETS, WINTER SEASON, 1972

Month	Greenhouse	Mexico	Florida	Other[a]	Total
	(carlots from each source)				
January	12	822	1469	84	2387
February	5	1535	1048	33	2621
March	15	2032	1236	29	3339
April	78	1923	1084	44	3129
May	257	1450	1823	267	3797
June	264	298	1223	2686	4471
November	117	217	997	1449	2780
December	55	239	1482	613	2389
Total	803	8516	10389	5205	24913

[a]Major supply from California

SOURCE: 8.

The following chart summarizes some of these factors for the major alternative production areas:

Comparison of Alternative Production Areas for Winter Vegetables

Factors	Greenhouse	Southern Florida	Mexico
Temperature	Optimum Ex. Late Sp.	Variable Cool-Freeze Hot Damage	Even-Sometimes Too Hot Too Cool
Rainfall-Water	Optimum	Variable (Alter.) Too Dry Too Wet	Irrigation Sometimes Rain Damage
Sun (Light)	Often Short	Optimum	Optimum
Distance to Market	Optimum Near	Distant	Extremely Distant
Market Quality	Good- Excellent	Variable Fair-Good	Variable Good
Labor	Good Expensive	Expensive	Plentiful Less Expensive
Land Area	Limited Costly	Plentiful	Plentiful
Initial Land & Blg. Investment*	$.50-.75/lb. Annual Sales	$ .25-.55/lb. Annual Sales	$.08-.12/lb. Annual Sales

*Estimates based on: 9, 10, 11.

These evaluations are somewhat subjective and do not attempt quantitative definitions of the deviations from the optimum for the factors listed. For any indicated designation other than optimum, however, problems occur that increase costs or reduce market quality. Since greenhouses offer the

greatest control of factors of production of any of the areas, the greenhouse producer sometimes benefits from adverse weather, transport or other problems affecting the less controlled competing areas. Many of the advances in technology, in transport, in irrigation, etc., reduce the advantage or increase the disadvantage of the greenhouse grower near the market.

"There are several reasons why the competition for greenhouse tomato producers is increasing. Some of these are:[12]

1. Continued decline in production costs and improvements in production practices in competing outdoor areas.
2. Improved varieties, especially for vine ripe shipment.
3. Speedier shipping schedules.
4. Much greater knowledge of physiological needs of the tomato after picking and in transit. This has allowed the harvest and sale of 'vine ripe' tomatoes.
5. Large supplies of relatively uniform tomatoes in 'vine ripe' shipping areas for large buyers.
6. Improved identification of the product as 'vine ripe.'

"The major advantage to the greenhouse industry in this competition is:

1. Higher quality -- Greenhouse tomatoes continue to have an appearance and eating quality that is superior to vine ripe tomatoes.
2. Location -- The advantage of being here and not 800-2500 miles away is more than a few cents a pound freight. It allows the chance for better understanding between buyers and sellers, more rapid correction of problems and quicker service. This advantage is being exploited by some greenhouse groups, but not by the industry as a whole.
3. More dependable supply -- The supply of greenhouse tomatoes is less subject to weather than that from competing outdoor areas."

Product quality is more variable for vine ripe than for greenhouse tomatoes, but the grading and sizing of vine ripe tomatoes is normally more uniform. An added problem for the greenhouse tomato grower is the fact that the customer sometimes cannot identify the greenhouse tomato and often assumes the uniformly graded vine ripe is, in fact, a greenhouse tomato.

Consumer panel tests over a three-year period in Columbus, Ohio, showed highly significant differences in rated qualities of the three types of tomatoes. On a scale of 1 = Poorest to 10 = Best, the average rating for greenhouse was 7.8, for vine ripe 6.1, and tube 4.3. The quality difference between greenhouse and vine ripe was much less than for greenhouse and tube quality.[13] With the quality differences shown one would expect more substitution by customers of vine ripe for greenhouse tomatoes than of tube for greenhouse tomatoes.

No studies of demand elasticity have been made since vine ripe tomato sale became a major factor in supplies. However, a study made in 1963 of fresh tomato production and price data for 1937-60 drew the following conclusions:[14]

"1. One percent year-to-year increase in the sales of greenhouse tomatoes results in a decrease of only 0.22 percent in the price of greenhouse tomatoes when other things are accounted for.
2. One percent year-to-year change in the spring production of field grown tomatoes in the U.S. results in about 0.11 percent change in the opposite direction in the price of greenhouse tomatoes.
3. One percent year-to-year change in the spring production of lettuce in the U.S. results in about 0.34 percent change in the same direction in the price of greenhouse tomatoes.
4. Year-to-year change of one percent in per capita personal income in 'market area' families results in about 1.5 percent change in the price of greenhouse tomatoes when other things are accounted for.
5. Year-to-year change of one percent in the index of freight rate results in about 0.58 percent change in the same direction in the price of greenhouse tomatoes when other things are accounted for.
6. A year-to-year price change of 0.71 percent in greenhouse tomatoes is associated with a one percent year-to-year change in the index of marketing cost."

Another study indicated a price elasticity of -7.90 for Ohio spring crop greenhouse tomatoes and a cross elasticity with tube tomatoes of 3.04.[15]

The highly elastic nature of the demand for greenhouse tomatoes was established in these studies prior to the time of the present importance of supplies of vine ripe tomatoes. It is considered likely that a similar study today might indicate even higher price elasticities and cross elasticities than were found here. It is also likely that consumer quality rating differences between greenhouse and competing tomatoes today would be quite different than during the period where the only alternative fresh tomato was the mature green or tube tomato.

The usual retail price for greenhouse tomatoes is higher than that for either vine ripe or tube tomatoes. In a 12-week, April-June, 1962, study in 214 Ohio retail food stores, average prices of greenhouse tomatoes were about 44.0 cents per pound compared with vine ripe at 39.2 and tube at 27.5 cents per pound.[16] Studies by the Department of Labor for the 1963-68 period show prices of tube tomatoes at about nine cents per pound less than those for loose (bulk) tomatoes.[1] The loose tomatoes are a mixture of vine ripe, greenhouse and large size mature green tomatoes sometimes sold erroneously as vine ripe tomatoes or even greenhouse tomatoes.

Despite a certain amount of confusion in consumer identification of tomatoes, the customary higher price for greenhouse tomatoes cannot help but have some effect in determining the type of customer purchasing these

tomatoes. Clearly, greenhouse tomatoes are considered different and superior by those who purchase them. Any comparison of greenhouse tomatoes produced near the market and tomatoes produced in climatically favored areas distant from market has an element of comparing unlike products as though they were, in fact, alike. Any such comparison includes a certain amount of error like comparing Cadillacs and Chevrolets under the assumption that either is a substitute for the other.

Cost Comparisons

Several studies in the past ten years have made limited comparisons of production costs of greenhouse and outdoor tomatoes possible. Despite the lack of comparable cost categories, the various studies show a wide difference in costs of greenhouse tomato producers on the one hand and Florida or Mexico outdoor tomato producers on the other (Table 5).

Total costs of producing, harvesting, packing and shipping point selling of tomatoes for distant, outdoor shipping areas were approximately 10 to 14 cents a pound less than costs for Ohio and Ontario greenhouses in the 1967-69 period. In the case of Mexican tomatoes, this also included hauling from the production area to Nogales. Transportation costs from these distant areas were about 4.0 cents a pound to northeastern U.S. points from Nogales and 2.5 cents a pound for Florida during this same period. Current trucking rates for tomatoes are approximately 3.8 cents per pound from Florida and about 5.2 cents per pound from Nogales to Cleveland, Ohio.[19] Rates are quite variable from week to week.

TABLE 5

ESTIMATED PRODUCTION AND SHIPPING POINT MARKETING COSTS
FOR FLORIDA, MEXICO AND CANADIAN GREENHOUSE TOMATOES

	Florida			Mexico		Canadian Greenhouses	Ohio
	Immokalee-Lee 1968-69	Palm Beach-Broward 1968-69	Palm Beach-Broward 1963-64 to 1967-68	1967	1967-68	1967	1967
	(cents per pound)						
Growing	8.0	9.5	5.9	2.8	1.5	20.1	---
Harvest and Shipping Point Sales Charges[a]	6.7	7.1	5.9	9.6	8.2	5.2	---
Total	14.7	16.6	11.8	12.4	9.7	25.3	26.1
Sales Value	13.8	15.3	13.6	14.0	---	---	---
Net Profit (Loss)	(-0.9)	(-1.3)	1.8	1.6	---	---	---
Yield Per Acre (Lb.)	24,160	24,080	34,240	14,280	36,000[b]	160,000	190,000

[a]These include all harvesting, grading, packing, and package costs and costs of first sale by producer. For Mexico, this also includes hauling to Nogales, Arizona, and all costs there including customs duties and charges.

[b]Estimated 21,600 pounds of exportable quality.

SOURCES: 9, 11, 17, 18

In the absence of more detailed cost studies, further comparisons must depend on rather gross estimates and assumptions of major factor costs in production and marketing. A comparison of the economy of use of three major input costs in supplying winter tomatoes to north central and northeastern U.S. by nearby greenhouses versus outdoor producing areas in Florida and Mexico suggests relative advantages of each area. The three input factors compared are labor, fuel and capital investment.

Labor

Any comparison of U.S. and Mexican wage rates is clouded by quality of labor and quantity needed per acre in production in the two areas. The Mexican farm wage rate, per day, is roughly equivalent to U.S. farm wage rates per hour. In Mexico in 1967-68, the estimated cost of labor for producing and harvesting a pound of vine ripe tomatoes was approximately 41 percent of the total cost of 2.5 cents per pound, or a labor cost of about 1.0 cents per pound.[11] Labor accounted for 31 percent of the total growing, harvesting, packing and farm selling costs of 4.6 cents per pound for Mexican vine ripe tomatoes.

The cost of labor of 10 to 12 cents per pound of greenhouse tomatoes in 1971 was approximately 40 percent of the total cost of producing and harvesting greenhouse tomatoes.[10] The total cost of producing, harvesting, grading and packing was 26.6 cents per pound for greenhouse tomatoes. Total costs of growing, harvesting and packing in Florida vine ripe areas were 14.2 and 16.7 cents a pound, approximately, in two areas in 1968-69.[9] No details were given on labor costs. Approximate total hours of labor for producing,

harvesting, grading and packing in Cleveland greenhouses in 1971 were 7250 hours per acre, compared with about 8350 hours in 1967-68 for a comparable quantity of Mexican tomatoes.

Clearly there is a labor cost advantage of approximately 8 to 10 cents per pound for the Mexican producer when compared with the greenhouse producer and the Florida producer. In addition to labor cost advantages, the Mexican producer enjoys a more readily available supply of labor than his U.S. competitor.

Fuel

Fuel costs are second only to labor in operating costs in U.S. greenhouses. In a 1971 study of nine Ohio greenhouses, fuel cost $8700 an acre for tomato production compared with $13,340 an acre for labor.

While it is too early to do more than speculate on the effects of the present fuel crisis on greenhouse heating costs for the long term, some estimates of the magnitude of the present changes can be made. Fuel costs for those using coal have increased by about 45 percent, from $21.57 to $31.18 per 2000 pound ton, since November, 1972.[20] The cost of heating oil has increased about 2.5 times during the same period. With tomato yields of 200,000 pounds per acre, these increases amount to from 2.0 to 5.0 cents per pound of tomatoes.

The current concern regarding fuel shortages and the extreme price increases in fuels suggest a simple comparison of differential fuel use by the nearby greenhouse and the producer in distant, climatically favored

production areas. If it is assumed that the major comparison is that for fuel for heating greenhouses with fuel for hauling vegetables from the distant area to population centers, the economy in fuel use favors the distant area. For ease in the comparison, fuel oil is used for both. Approximately 80,000 to 100,000 gallons of fuel oil are needed per year per acre of greenhouse under Ohio conditions (Table 6). This includes fuel for once a year soil sterilization. For transport, the 40,000 pound capacity trucks travel four to four and one-half miles per gallon of diesel fuel. With a distance from Mexico to northeast and north central U.S. of approximately 3200 miles, and from Florida of 1000 miles, the fuel use compares as shown in Table 6. Heating for greenhouse production uses from 10 to 30 times the fuel needed for transport of a similar quantity of tomatoes from climatically favored areas, or more than an additional 2.5 pounds of fuel for each pound of tomatoes.

Capital

Capital needs vary widely between outdoor and greenhouse production areas. The greenhouse is the most intensive producing unit in commercial agriculture. Depending on the degree of automatic environmental control desired, new greenhouse construction costs range from $125,000 to more than $215,000 per acre. New plastic houses in California with appropriate heating and cooling equipment cost approximately $109,810 per acre.[3] If it is assumed that the land value in greenhouse areas is similar to that in distant areas (i.e., one acre greenhouse versus five to ten acres outdoor for equivalent production) and that packinghouse and other auxiliary needs

TABLE 6

ESTIMATED DIFFERENTIAL FUEL REQUIREMENTS FOR WINTER TOMATO PRODUCTION IN GREENHOUSES AND IN DISTANT, CLIMATICALLY FAVORED AREAS

	U.S. Gals. of Oil for Heating[a]	U.S. Gals. of Oil for Transport[a]
Florida (1000 miles)	---	2500
Mexico (3200 miles)	---	8000
Greenhouse (N.E. U.S.-- 0 miles)	80,000	---[b]
Total for equivalent tonnage	80,000	1240 - 4000

Greenhouse -- 10 to 30 times fuel use

or more than 2.5 additional pounds of fuel per pound of tomatoes

[a]Both the greenhouse and outdoor estimates are for 200,000 pounds of tomatoes.

[b]Assume local distribution for greenhouse and equivalent distribution for "imported" outdoor tomatoes after reaching northern cities are equal.

are similar in the competing production areas, the capital needs are approximately as shown in Table 7. The capital needs for transport and production investment other than land are six to ten times as great or perhaps an additional 50 to 60 cents more investment per pound of annual tomato production in greenhouse than in distant, climatically favored areas.

The end result of the differential costs and utilization rates of these three factors, and other costs not treated separately, is a major cost advantage to the distant, climatically favored production areas for winter tomatoes (and other winter vegetables). In 1967-68, this cost advantage for delivery to New York City was about 13.1 cents per pound for Mexico and 14.6 cents for Florida. Delivery to Chicago from Mexico was approximately 14.2 cents a pound less than from Ohio greenhouses, while from Florida the advantage over greenhouse costs was about 13.8 cents a pound (Table 8).

Conclusions and Comments

The limited and admittedly fragmentary comparisons of nearby greenhouse and distant climatically favored vegetable production for the winter market suggest the following conclusions:

1. Success of winter vegetable production under environmentally controlled conditions in greenhouses near to market depends on obtaining premium prices per unit rather than any competitive cost advantage over distant outdoor, climatically favored areas of production. This has been

TABLE 7

ESTIMATED DIFFERENTIAL CAPITAL REQUIREMENTS FOR WINTER TOMATO PRODUCTION IN GREENHOUSES AND IN DISTANT, CLIMATICALLY FAVORED AREAS[a]

Production Areas	Land	Equipment[c]	Facilities[d]
Florida	---[b]	$6500-10000	---
Mexico	---[b]	$15000-20000	---
Greenhouse	---[b]	---	$125-215000

Greenhouse capital requirements are 6 to 10 times greater than distant

[a]For 200,000 pounds of tomatoes or one acre greenhouse equivalent.

[b]Assume similar costs for quantity of land needed to produce 200,000 pounds.

[c]Only the truck investment is shown (an $80,000 truck needed 1/6 to 1/4 year for hauling 200,000 pounds of tomatoes from Mexico to northeastern U.S., or about 1/12 to 1/8 year for Florida). Field production equipment values for the three locations roughly comparable.

[d]Only the greenhouse structure and equipment shown. Costs of packinghouse, grading and packing equipment similar for two areas and types.

TABLE 8

ESTIMATED COST OF PRODUCTION, HARVESTING, MARKETING AND DELIVERY TO SPECIFIC DESTINATIONS, 1967-68

	Delivered to:	
	New York	Chicago
Florida Vine Ripe Tomatoes	12.9¢/lb.	13.2¢/lb.
Mexico Vine Ripe Tomatoes	14.4¢/lb.	12.8¢/lb.
Ohio Greenhouse	27.5¢/lb.	27.0¢/lb.

SOURCES: 11, 18

true in the past and will continue to be the case regardless of the solution of the present energy crisis. The higher the fuel price, the greater the relative disadvantage of the producer depending on environmental controls.

2. The role of the greenhouse in winter vegetable production in the U.S. has been and seems destined to continue to be the supplying of a premium quality product to a small share of the market. While greenhouse producers presently supply only three to four percent of the winter tomato needs, the volume involved is sufficient to support a viable greenhouse tomato industry in the U.S. Continued success will depend on adopting sales and merchandising policies to exploit the real quality differences in the greenhouse product rather than in competing on a price per pound basis with distant, climatically favored producers.

3. While the proportion of the population that can afford a premium quality greenhouse product will grow as people become more affluent, the improved quality vine ripe tomato will share increasingly in this premium market.

4. The current energy crisis intensifies the competitive disadvantage of producers in environmentally controlled structures, but a return to fuel prices of the 1960's would not remove this disadvantage. Only a major breakthrough such as inexpensive atomic fuel could significantly alter the competitive situation in favor of greenhouse production.

5. Trends in supply sources for winter vegetables indicate a clear competitive advantage to Mexican production areas over those in Florida

and other U.S. areas. In the absence of import restrictions such as import quotas or higher import duties, the percentage of winter vegetables from Mexico seems destined to continue to increase.

6. New developments in technology, transportation systems, international trade, governmental price and market controls, and marketing institutions could drastically alter the competitive climate in favor of either production area.[7] Winter vegetables are especially vulnerable to political action since major climatically favored areas are outside U.S. boundaries and subject to import restrictions. The costs and the uncertainties of political intervention help reduce the advantage to the foreign, climatically favored area.

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